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THE POISON GLANDS OF NOTURUS AND SCHILBEODES

HUGH DANIEL REED

THE eleven species of Noturus and Schilbeodes are popularly known as "stone cats" and "mad toms." They are small catfishes found in the lesser streams from New York and New Jersey west to Wyoming and Montana, and south to Georgia, Alabama and Texas, being most abundant in the Great Lake, Ohio and Upper Mississippi regions. They may be distinguished from other catfishes by the presence of a *keel-like* adipose fin joined to the back and more or less continuous with the caudal fin. The two genera, which appear very much alike, may be distinguished from each other by means of the pad of villiform teeth on the upper jaw. In Noturus this pad of teeth, at each outer caudal angle, possesses a backward extension which is absent in Schilbeodes.

It has long been known that the mad toms can inflict a painful wound with their pectoral spines. The sensations produced by the wounds, and the presence of a pore in the axilla, have led to much speculation respecting the presence of a poison-secreting gland which anoints the spine. Some take it for granted that such an organ exists, others are doubtful, and recently the presence of poison glands in these fishes has been denied altogether.

Günther ('80 b) recognized the existence of a sac in the axilla of certain catfishes and says,— "It does not seem improbable that it contains a fluid which may be introduced into a wound by means of the pectoral spine.... However, whether this secretion is equally poisonous in all the species provided with that axillary sac, or whether it has poisonous qualities at all, is a question which can be decided by experiments only made with the living fishes."

Jordan and Gilbert ('82) under the description of the genus Noturus[1] say,— "In or above the axil of the pectoral fins is an orifice, which is the opening of the duct of a poison gland." To this is added a quotation from Cope,— "From it [the pore] may frequently be drawn a solid gelatinous style ending in a tripod, each limb of which is dichotomously divided into short branches of regular length." Jordan and Evermann ('96) make a similar statement and add,— "The sting from the pectoral spine is very painful, resembling the sting of a bee, but worse." Again, Jordan ('04) writes the following footnote,— "The wounds produced by the sting of their sharp pectoral spines are excessively painful. In the axil is usually a pore, probably the opening of a duct from a poison gland. This matter deserves investigation." Finally ('05) he writes,— "In two genera, Noturus and Schilbeodes, a poison gland exists at the base of the pectoral spine, and the wound gives a sharp pain like the sting of a hornet and almost exactly like the sting of a scorpion-fish."

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[1] What now constitute the genera Noturus and Schilbeodes were then included under the generic term Noturus.

Boulenger ('04) does not consider this axillary sac a poison gland. In this connection he says,— "I think this condition of things has nothing to do with a poison organ, and is merely a repetition of what is observed in loaches and in the characinid Xenocharax, where I have found a gelatinous substance filling the short duct by which the membrane of the air bladder is placed in communication with the skin and the sensory organ of the lateral line."

Poison organs in connection with various spines have been found in several different groups of fishes. Günther ('69) has described a poison apparatus in *Thalassophryne reticulata* which inflicts a wound followed by poisonous symptoms. At the base of the dorsal and opercular spines in this species he found a sac connected with a canal passing through the whole length of the spine and opening through a slit at its distal extremity. Thus the spine resembles the fang of a poisonous snake. Günther concluded by saying, "Nobody will suppose that a complicated apparatus like the one described can be intended for conveying an innocuous substance and therefore I have not hesitated to designate it as poisonous; and Capt. Dow informs me in a letter lately received, that 'the natives of Panama seemed quite familiar with the existence of the spines and of the emission from them of a poison which, when introduced into a wound, caused fever, an effect somewhat similar to that produced by the sting of a scorpion;

but in no case was a wound caused by one of them known to result seriously. The slightest pressure of the finger at the base of the spine caused the poison to jet a foot or more from the opening of the spine'."

The weever fishes (Trachinus) found along the coast of Europe inflict very severe wounds with their dorsal and opercular spines. This was so well known that in some towns, at one time, there were regulations providing for the removal of the spines before the fishes were displayed in the markets. Schmidt ('75) and Parker ('88) independently found well developed glands about the dorsal and opercular spines. There are numerous references to the poisonous nature of the weever fishes, but the two authors mentioned are the only ones, so far as I know, who have described the structure of the glands.

Wallace ('93) in the toadfish, *Opsanus* (*Batrachus*) *tau*, discovered glands in connection with pores in the axilla, on the dorsal portion of the operculum and on the surface of the pectoral fin. This author does not consider them as poison glands although the spines of this species give a "slightly painful sting" and the glands apparently are of the same type as those of the weever fishes described by Schmidt and Parker, and those of the mad toms to be described presently.

With the above facts and views in mind and a desire to know more of the action and structure of the supposed poison glands, all the known species[1] of Noturus and Schilbeodes, except *S. funebris*, have been examined. The sting will be described first, and then the structure of the glands.

The Sting.— The sting of the mad toms has been described as like that of a bee. In *Schilbeodes gyrinus* the sensations produced do not differ materially from those of a bee but as a rule the pain is not so intense and is usually confined to the wounded region. Frequently a very severe sting upon the end of the finger caused pain throughout the hand and wrist. In several cases after receiving deep punctures on the end of the finger, sharp pains which continued for several hours, were experienced to the elbow. Dr.

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[1] The author wishes to acknowledge his indebtedness to Dr. C. H. Eigenmann, Dr. B. W. Evermann and the authorities of the National Museum for the generous loan of specimens for study.

Evermann (MS.) describes the pain as, "A very stinging sensation, more like that which would result from a severe nettle sting.' This describes precisely the majority of stings, for in handling live specimens ordinarily only the tip of the spine enters the flesh. The mechanical injury is so slight that it frequently is impossible to locate the wound except for the stinging sensation. From an ordinary sting, such as is received in handling the live fishes, the pain continues from one to several hours, depending probably upon the amount of poison entering the wound. Both in sensation and duration these wounds differ from those made by the prick or puncture of a sharply pointed instrument. The swelling is hardly perceptible,[1] except in cases of very severe punctures, in which event the flesh about the wound becomes distinctly swollen and slightly discolored. Similar results, but more marked, are produced by introducing a portion of a fresh gland underneath the skin.

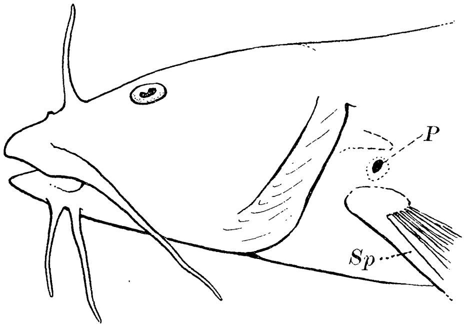

FIG. 1.— The head of *Noturus flavus*. *P*, axillary pore or opening of axillary gland. Sp, pectoral spine.

The Poison Glands.— All the species of Noturus and Schilbeodes possess axillary glands which open through a pore situated in the axilla just below the post humeral process (Fig. 1, *P*). The position of the pore with reference to the base of the fin and the humeral process varies somewhat in different species. In all, the pore is more or less slit-like and is situated so that when the fin is adducted the spine lies either directly across or parallel with it. Thus the transfer of secretions to the spine may be accomplished during adduction but it is doubtful if this is the usual method of anointing the spines. In most of the species the pore is opened widely when the fin is abducted. In *Schilbeodes insignis* the lips of the pore, if anything, are drawn closer together by the abduction of the fin. In approaching each other, however, the lips of the pore are continued to the base of the spine as two slight folds with a groove between them. Thus the secretions would find a safe conduit from the pore to the spine.

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[1] *Schilbeodes gyrinus* was the only species available for experimentation. Some other species of the genus are said to be more virulent.

The glands are pear-shaped, with the apex toward the axillary pore (Fig. 2, p. g. and p. o.). In most species examined, the gland is inclined backwards and lies just beneath the skin and entad of the posthumeral process (Fig. 2, h). It is surrounded by loose connective and adipose tissue. In *S. gyrinus* the gland extends farther towards the head than in some other species. In all species the gland, though small, is macroscopic. In a specimen of *Noturus flavus* 17 cm. long the greatest diameter of the gland was 5 mm.

The glands are divided into three main lobes, each of which is subdivided into lobules. The lumen of the gland is extremely narrow except near the pore where it is comparatively wide. It can be traced in sections however, through the main lobes and for a short distance into the subdivisions. The tripod style which Cope withdrew from the pore was probably the hardened secretion of the gland, each of the three legs of the style corresponding to the lumen of the three main divisions of the duct and the dichotomous branches repre-

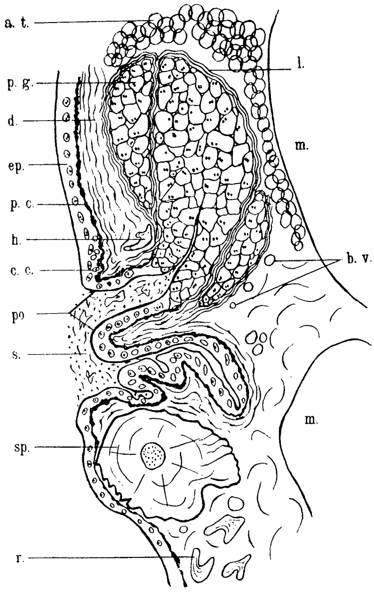

FIG. 2.— Section through the axillary gland and pectoral spine of *Schilbeodes miurus*. *a. t.*, adipose tissue. *p. g.*, axillary poison gland. *d.*, corium. *ep.*, epidermis. *p. c.*, layer of pigment cells. *h.*, post-humeral process. *c. c.*, clavate cells of the epidermis. *po.*, axillary pore. *s.*, secretion. *sp.*, pectoral spine. *r.*, fin-ray. *l.*, sheath of the gland. *m.*, muscle. *b. v.*, blood vessels.

senting the lumens of further subdivisions. I have frequently found globular masses of the secretion filling and depending from the pore (Fig. 2, s) but have been unable to withdraw one with the branches intact. The secreting cells are granular and very large. They range between 80 and 200 microns in their greatest diameter, and vary in shape due to compression with neighboring cells. Most of the cells contain two large nuclei. As a rule the two nuclei are separated by a short space, but frequently they are found very close together or apparently joined. This may indicate recent division as Parker has suggested in connection with similar phenomena in the poison glands of the weever fishes. Further evidence of division has not been apparent.

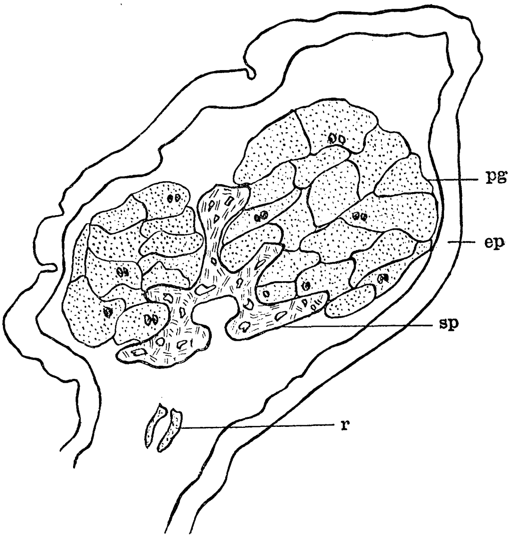

FIG. 3.— Transection of the dorsal spine of *Schilbeodes gyrinus*. *pg*, poison gland. *ep*, epidermis. *sp*, dorsal spine. *r*, fin-ray.

The entire gland is surrounded by a sheath which reaches the bottom of the fissures between the primary and secondary lobes. (Fig. 2, l). Every secreting cell is lodged in a loose network of elongated spindle-shaped cells which Schmidt has named supporting cells. Each has a nucleus in its central part. The gland is richly supplied with blood vessels which are lodged in its sheath and between its lobes.

Besides the axillary glands, two species, *Schilbeodes gyrinus* and *S. nocturnus,* each possess glands beneath the skin which covers the dorsal and pectoral spines. Both spines are situated in front of and are shorter than the first soft rays of their respective fins. Both are grooved, as shown in the transection Fig. 3, sp. Near the base of the spines the grooves are more complex. If an uninjured specimen be examined, at the middle of the extent of these spines there will be noticed a swelling which tapers towards either end. The gland (Fig. 4, pg) is coextensive with this swelling and occupies nearly all of the space between the skin and the spine which it surrounds (Fig. 3, pg). At the end of the spine there is a slit in the epidermis through which the spine projects slightly. In preserved specimens it is not unusual to find a globular mass or a long filament of the hardened secretion attached to the end of these spines. The sting of the dorsal spine in *Schilbeodes gyrinus* is precisely like that of the pectoral. The

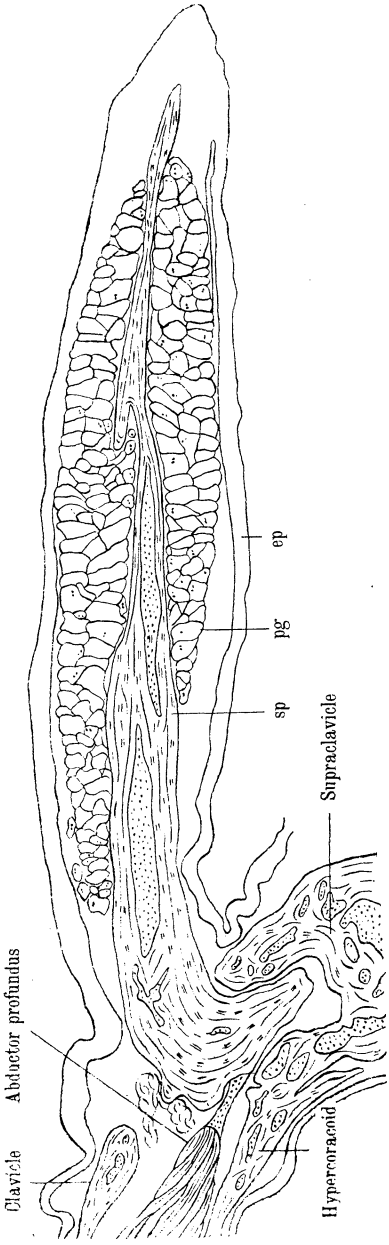

FIG. 4.— Longitudinal section of the pectoral spine of *Schilbeodes gyrinus*. *sp*, pectoral spine. *pg*, poison gland. *ep*, epidermis.

same will probably be found true of *S. nocturnus* for the dorsal spine gland is here as well developed as the pectoral. The presence of spine glands may be determined by carefully slitting the overlying skin and scraping the spine with a needle. If the gland is present, the scrapings when stained and mounted show the typical gland structure almost as clearly as sections. Sometimes the structure can be made out with a dissecting lens without either staining or scraping the tissue from the spine. In the fresh condition the glands are of a translucent jelly-like consistency and appearance. There is no difference in structure between the axillary and spine glands.

It appears from the figures and descriptions of Schmidt and Parker that the poison organs of the mad toms and the weever fishes are identical in structure. In the latter group the glands are found only in connection with the opercular and dorsal spines which they surround in precisely the same manner as do the pectoral and dorsal glands of *Schilbeodes gyrinus* and *S. nocturnus*.

Differential stains fail to reveal the presence of any muscular fibers which might by their contraction exert pressure upon the cells and force their secretions to the exterior. The same is true according to Schmidt and Parker of the weever fishes. The latter ('88) writes,— "No special muscles are present in connection with the glands. . . . I am inclined to think that in the discharge of their secretions the cells simply burst." Schmidt ('75) observes that "Along the ventral side of the upper gland are found a few bundles of the extensor muscle of the gill cover but they could hardly produce any pressure on the gland, and moreover, no organ, adapted for active ejection of the secretion, is found." It appears that the cells are destroyed when the secretions are released, for in no case has a natural opening been found in the cells, and the secretions when stained are found to contain ruptured and ragged cells in many of which the nucleus can still be made out. Frequently uninjured cells are found floating in the secretions along with the ruptured ones. Usually these are small cells, probably immature ones, which have been torn away with the others.

The relation of the fin and body muscles to the gland is such that no amount of contraction can produce any pressure upon it.

It is improbable that the glands depend upon the application of external pressure, such as would result if the fish were seized in the axillary region by another animal. It is doubtful whether, in those species which possess spine glands, the spines are ever inserted far enough into the flesh of the victim to produce pressure as a result of the slipping of the skin away from the tip and towards the base of the spine. Such was Byerley's ('49) explanation of the ejection of the poison from the glands of the weever fishes but it was not accepted later by Schmidt and Parker. Judging from the size of the wound inflicted by these forms which possess spine glands, the exposed portion of the spine is probably as much as is usually inserted into the flesh. It seems probable that the cells of both axillary and spine glands are ruptured from the outward pressure exerted by their own contents. The ruptured cells are not found in one place but are scattered through the gland, and the secretion may be seen streaming through the lumen and pore, out along the folds of skin on the dorsal surface of the spine toward its tip. In specimens which have been carefully handled a globule will be found depending from the axillary pore or a stream of the secretion extending from it to the pectoral spine. The end of the pectoral and dorsal spines in *Schilbeodes gyrinus* is usually found with a globule or wavy filament of the poison. Thus always supplied with poison at its very tip it can be readily understood how the slightest prick produces results.

It is worthy of note that spine glands are found only in those species where serrae upon the spines are absent or very few and weak. A serrate dorsal spine without a gland apparently cannot inflict a stinging wound, but the non-glandular serrate pectoral spines are supplied with poison from the axillary glands. Although no difference in the relative size or specialization of the axillary glands in the two groups has been noted, the species with serrae are considered more poisonous than those without. The presence of serrae makes possible the infliction of a large number of wounds and consequently the introduction of a large amount of poison at one and the same time. This would render such species more formidable although the poison is secreted in smaller quantities and is no more virulent. Certainly spines without serrae can inflict wounds from the tip end only and being some distance from the axillary pore would most likely be poorly provided with poison except for the presence of a gland opening at the very end. It seems plausible, therefore, that the absence of serrae is correlated with the presence of glands developed about the spines, as in *Schilbeodes gyrinus* and *S. nocturnus* and as probably will be found in *S. leptacanthus*[1] when an uninjured individual is examined.

The Origin of the Gland Cells.— Cutaneous glands are generally to be regarded as invaginations or proliferations of the epidermis, certain cells of which become transformed into the secreting cells. Wallace ('93) has shown that in the axillary glands of the toadfish the clavate cells of the epidermis become the secreting cells, whereas the smaller cells become the supporting elements. Similarly, in writing of the weever fishes, Schmidt says,— "After a comparison of the contents of the gland sac and the adjacent epidermis it seems clear that in the gland tissue the secreting cells replace the clavate cells and that the ordinary epidermal cells are gradually transformed into the supporting plexus." Parker calls attention to the lack of well defined ducts in the glands of the weever fish. He says,— "There can be little doubt that the gland is developed as an epidermic involution the whole of which gives rise to secre-

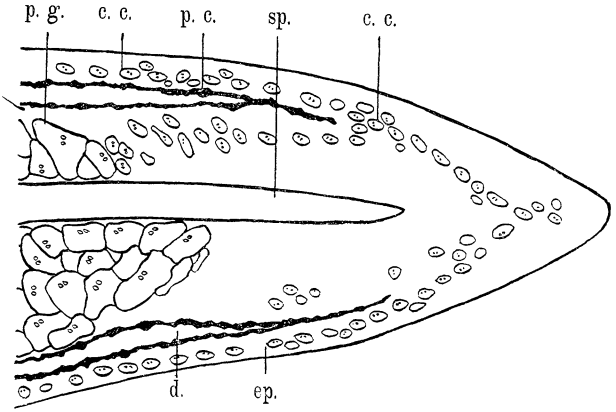

FIG. 5.— Longitudinal section of the end of the pectoral spine of *Schilbeodes gyrinus*. *p. g.*, poison gland. *c. c.*, clavate cells. *p. c.*, layer of pigment cells. *sp.*, pectoral spine. *d.*, corium. *ep.*, epidermis.

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[1] The only specimen available was a very small one, the spines of which had been denuded of all tissue whatsoever.

tory cells, so that there is no marked differentiation into gland and duct."

The glands in Noturus and Schilbeodes are likewise invaginations of the epidermis. They are surrounded by a sheath of corium pushed inward by the developing gland. As shown in Fig. 2, *d* and *l*, the sheath is thinner and denser than the rest of the corium, with which it is continuous around the neck of the gland. Between the corium and epidermis in most regions of the body there is a layer of pigment cells (Fig. 2, p. c.) which is frequently found to extend about the gland between the sheath and the gland tissue, thus occupying the same relative position as in the skin. The arrangement of the pigment layer in relation to the spine glands shows that they are invaginated from near the tip of the spine. Near the tip, the pigment layer (Fig. 5, p. c.) turns upon itself and passes over the gland to its base, toward the root of the spine. Thus the gland is invested by two layers of pigment cells with corium between them (Fig. 5, d). The clavate cells of the skin and the secreting cells of the gland form an uninterrupted series (Fig. 5, c. c. and p. g.), the former gradually increasing in size so that in sections it is sometimes impossible to draw the line between the two. The other cells of the epidermis as the gland is approached, gradually assume an irregular shape, then becoming more elongated they are finally transformed into the extremely slender cells which constitute the supporting tissue.

The invagination is much more extensive and the specialization of elements proceeds much further in the mad toms than in the toadfish. In the glands of the latter the epidermal character of the cells is barely lost. Thus the slime cells, which in the mad toms are apparent only in the skin, according to Wallace's figures are perfectly distinct in the glands of the toadfish, and project into the gland cavity.

SUMMARY

1. All of the species of Noturus and Schilbeodes, except *S. funebris*, have been examined; they are found to possess an axillary pore which is the opening of a gland.

2. Experiments with *Schilbeodes gyrinus* indicate that the secretions of the glands are poisonous.

3. In addition to the axillary glands *Schilbeodes gyrinus* and *S. nocturnus* possess glands developed about the pectoral and dorsal spines. These are of the same type and structure as the axillary glands. The end of such a gland-bearing spine projects slightly through a slit in the epidermis.

4. Spine glands are not found in those species which possess well developed serrae upon the spines.

5. *Schilbeodes leptacanthus*, because of its close relation to *S. gyrinus*, would be expected to possess spine glands in addition to the axillary glands.

6. A study of the mature glands tends to justify the following conclusions:

   a. The glands are of epidermal origin; those in the axilla invaginate from the pore, and those in the spines from the slits near the tips of the spines.
   b. The gland sheath is modified corium.
   c. The clavate cells of the skin become the secreting cells of the gland.
   d. The ordinary epidermal cells become elongated, forming the supporting network of the secreting cells.
   e. The glands of the mad toms are essentially like those of the weever fishes.
   f. The glands of the toadfish, although of the same type, are intermediate in structure between the glands of the mad toms and unmodified epidermis.
   g. There are no muscles for rupturing the cells and forcing out the secretion. The cell walls are evidently ruptured by the pressure of their contents. In this way the spines are constantly anointed with the poisonous secretion as may be seen by examining uninjured specimens.

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LITERATURE.

ALLMAN, G. J.

'41. On the Stinging Property of the Lesser Weever. (Trachinus). *Ann. Nat. Hist.* 1841, vol. 6, p. 161.

BOULENGER, G. A.

'04. The Cambridge Natural History, *Fishes, Ascidians, etc.*, 1904, vol. 7, p. 590. Macmillan Co., N. Y.

BRIDGE, T. W.

'04. The Cambridge Natural History, *Fishes, Ascidians, etc.*, 1904, vol. 7, p. 177. Macmillan Co., N. Y.

BYERLEY.

'49. Poison of Weever Fishes. *Proc. Literary and Philosophical Soc.*, Liverpool, 1849, p. 156.

CHIEVITZ, J. H.

'88. Notice on Professor W. Newton Parker's Communication, "On the Poison Organs of Trachinus." *Anat. Anz.*, 1888, p. 787.

CUVIER. [Remarks upon the poison of the weever fishes]. *Hist. Nat. des Poissons.* T. 3, p. 184.

DAY. [Remarks upon the poison of the weever fishes].

'80–'84. *The Fishes of Great Britain and Ireland*, vol. 1, pp. 78–82. London.

GESSIN, LEON.

'84. Contributions à l'étude de l'appareil a venin chez les poissons du genre "vive" (Trachinus). *Thèse de Paris.* 1884.

GÜNTHER, A.

'64 On a Poison Organ in a genus of Batrachoid Fishes. *Proc. Zool. Soc. Lon.*, 1864, p. 157.

'69. An account of the Fishes of the States of Central America Based on Collections made by Capt. J. M. Dowe, F. Godman Esq., and O. Salvin Esq., *Trans. Zool. Soc. Lon.*, 1869, vol. 6, p. 439.

'80 a. Article on "Ichthyology" in *Ency. Brit.*, 1880, vol. 12, p. 190.

'80 b. An Introduction to the Study of Fishes. Edin., 1880. p. 192.

JARDIN, SIR WM.

'43. British Fishes, pt. 1. *Naturalists Library*, 1843, vol. 4 (Ichthyology), pp. 135–137.

JORDAN, D. S.

'04. Manual of Vertebrates. 1904, p. 41, McClurg & Co., Chicago.

'05. A Guide to the Study of Fishes. 1905, vol. 2, p. 177. Henry Holt & Co., N. Y.

JORDAN, D. S. AND GILBERT, C. H.

'82. Synopsis of the Fishes of North America. *U. S. Nat. Mus.*, 1882, bull. 16, p. 98.

JORDAN, D. S. AND EVERMANN, B. W.

'96. The Fishes of North and Middle America. *U. S. Nat. Mus.*, 1896, bull. 47, p. 145.

KENT, W. SAVILLE.

'83. British Marine & Fresh Water Fishes. *Fisheries Exhibition Handbook*, 1883, p. 29. London.

PARKER, W. N.

'88. On the Poison Organs of Trachinus, *Proc. Zool. Soc. London*, 1888, p. 359.

SACCHI, MARIE.

'95. *Atti. Soc. Ligust.*, 1895, vol. 6, p. 89.

SCHMIDT, F. T.

'75. Om Fjarsingens Stik og Giftredskaber. *Nord. Med. Arkiv.*, 1875, vol. 6, nr. 2.

TYBRING, OSCAR.

'86. Poisonous Fishes. (Translated from the Danish by Hermann Jacobson). *Bull. U. S. F. C.*, 1886, vol. 6, p. 148.

WALLACE, LOUISE B.

'93. The Structure and Development of the Axillary Glands of Batrachus. *Journ. Morph.*, 1893, vol. 8, p. 563, pl. 27.

WIEDERSHEIM, R.

'06. Vergleichende Anatomie der Wirbelthiere. 1906, Jena.

WRIGHT, R. R.

'84. *Proc. Can. Inst.*, 1884, vol. 2, p. 252.